USB Type-C ENGINEERING CHANGE NOTICE

Title: Cable for USB4™ Gen2 Clarification
Applied to: USB Type-C Specification, Release 2.0

Brief description of the functional changes proposed:
Clarify and change USB3.2 Gen1 cable requirements, which is needed for USB4 Gen2 operation. Based on lab test results, some of parameter limits of the specification need adjustment for USB4 Gen2 operation.

Benefits as a result of the proposed changes:
For future USB 3.2 Gen1 cable assemblies, the specification is tightened in order to support both USB 3.2 Gen 1 and USB4 Gen2 applications. The changes also provide clarification for CTS development.

An assessment of the impact to the existing revision and systems that currently conform to the USB specification:
Current cable assemblies that meet the old specification should still perform in USB3.2 Gen1 system.

An analysis of the hardware implications:
None

An analysis of the software implications:
None

An analysis of the compliance testing implications:
Clarify for CTS.

Actual Change Requested

(a). In Section 3.7.2.3.1, delete the exception for the USB SuperSpeed Gen 1- only Type-C to Type-C cable assembly.

From Text:

The USB SuperSpeed Gen 1-only Type-C to Type-C cable assembly is allowed by this specification and shall comply with the following insertion loss fit at Nyquist frequency requirements:

- ≥ –7.0 dB at 2.5 GHz, and
- > –12 dB at 5 GHz.

This insertion fit at Nyquist frequency allows the USB SuperSpeed Gen 1-only Type-C to Type-C cable assembly to achieve an overall length of approximately 2 meters.

To Text:

~~The USB SuperSpeed Gen 1-only Type-C to Type-C cable assembly is allowed by this specification and shall comply with the following insertion loss fit at Nyquist frequency requirements:~~

- ~~≥ –7.0 dB at 2.5 GHz, and~~
- ~~> –12 dB at 5 GHz.~~

~~This insertion fit at Nyquist frequency allows the USB SuperSpeed Gen 1-only Type-C to Type-C cable assembly to achieve an overall length of approximately 2 meters.~~

(b). After Section 3.7.2.3, add a section for USB 3.2 Gen1 cable assemblies – all following sub-sections numbers increment by 1 (i.e. existing 3.7.2.4 → 3.7.2.5, etc.).

From Text:

To Text:

3.7.2.4 TX/RX Passive Cable Assembly Requirements for USB 3.2 Gen1 and USB4 Gen2 (Normative)

3.7.2.4.1 Insertion Loss Fit at Nyquist Frequencies

The integrated S-parameter requirements for USB 3.2 Gen1 and USB4 Gen2 follow the same methodology as defined in Section 3.7.2.3. There are parameter adjustments made to suit the *USB4* Gen2 data rate. Unless otherwise specified, the following parameters shall be used to calculate insertion loss fit and integrated parameters:

- T_b, the unit interval, is set to 100 ps, reflecting the *USB4* Gen2 data rate.

- T_r, the rise time, remains at 0.4 * T_b.
- f_{max}, the maximum frequency over which the integration or fitting is performed is up to 12.5 GHz.
- The fitting equation is defined by the following equation:

$$IL_{fit} = a + b * \sqrt{f} + c * \sqrt{f^2} + d * \sqrt{f^3}$$

where f is the frequency and a, b, c, and d are the fitting coefficients.

The insertion loss fit at Nyquist frequency (ILfitatNq) shall meet the following requirements:

- ≥ −7.0 dB at 2.5 GHz, and
- > −11.5 dB at 5 GHz.

.

3.7.2.4.2 Integrated Multi-reflection

The insertion loss deviation, ILD, is defined as

$$ILD(f) = IL(f) - ILfit(f)$$

It measures the ripple of the insertion loss, caused by multiple reflections inside the cable assembly (mated with the fixture). The integration of *ILD(f)* is called the integrated multi- reflection (IMR):

$$IMR = dB\left(\sqrt{\frac{\int_0^{f_{max}} |ILD(f)|^2 |Vin(f)|^2 df}{\int_0^{f_{max}} |Vin(f)|^2 df}}\right)$$

where *fmax* = 12.5 GHz and *Vin(f)* is the input trapezoidal pulse spectrum.

For USB 3.2 Gen1 and USB4 Gen2 cable assemblies, IMR limit is specified as:

$$IMR \leq 0.126 \cdot ILfitatNq^2 + 3.024 \cdot ILfitatNq - 24.792.$$

3.7.2.4.3 Integrated Crosstalk between TX/RX Pairs

The integrated crosstalk between all TX/RX pairs is calculated with the following equations:

$$INEXT = dB\left(\sqrt{\frac{\int_0^{f_{max}} (|Vin(f)|^2 (|NEXT(f)|^2 + 0.125^2 \cdot |C2D(f)|^2) + |Vdd(f)|^2 \, |NEXTd(f)|^2) df}{\int_0^{f_{max}} |Vin(f)|^2 df}}\right)$$

$$IFEXT = dB\left(\sqrt{\frac{\int_0^{f_{max}} (|Vin(f)|^2 (|FEXT(f)|^2 + 0.125^2 \cdot |C2D(f)|^2) + |Vdd(f)|^2 \, |FEXTd(f)|^2) df}{\int_0^{f_{max}} |Vin(f)|^2 df}}\right)$$

where *NEXT(f)*, *FEXT(f)*, and *C2D(f)* are the measured near-end and far-end crosstalk between TX/RX pairs, and the common-mode-to-differential conversion, respectively. The factor of 0.125^2 accounts for the assumption that the common mode amplitude is 12.5% of the differential amplitude. *NEXTd(f)* and *FEXTd(f)* are, respectively, the near-end and far-end crosstalk from the D+/D− pair to TX/RX pairs. *Vdd(f)* is the input pulse spectrum with Tb=2.08 ns.

The largest values of INEXT and IFEXT shall meet the following requirements:

- INEXT ≤ −40 dB to 12.5GHz, for TX1 to RX1, TX2 to RX2, TX1 to RX2, TX2 to RX1, TX1 to TX2, and RX1 to RX2,
- IFEXT ≤ −40 dB to 12.5GHz, for TX1 to RX1, TX2 to RX2, TX1 to RX2, TX2 to RX1, TX1 to TX2, and RX1 to RX2.

The port-to-port crosstalk (TX1 to RX2, TX2 to RX1, TX1 to TX2, and RX1 to RX2) is specified to support the usages in which all the four high speed pairs transmit or receive signals simultaneously (e.g., USB dual-lane operation).

3.7.2.4.4 Integrated Crosstalk between TX/RX Pairs to USB 2.0 D+/D−

Crosstalk from the TX/RX pairs to USB 2.0 D+/D− shall be controlled to ensure the robustness of the USB 2.0 link. Since USB Type-C to Type-C Full-Featured cable assemblies may support the usage of *USB 3.2*, *USB4* or an Alternate Mode (e.g., DisplayPort™), the crosstalk from the four high speed differential pairs to D+/D− may be from near-end crosstalk, far-end crosstalk, or a combination of the two. The integrated crosstalk to D+/D− is calculated with the following equations:

$$\mathrm{IDDXT\_1NEXT + FEXT} = dB\left(\sqrt{\frac{\int_0^{f_{max}} |Vin(f)|^2 (|NEXT1(f)|^2 + |FEXT(f)|^2) df}{\int_0^{f_{max}} |Vin(f)|^2 df}}\right)$$

where:

NEXT = Near-end crosstalk from TX pair to D+/D−

FEXT = Far-end crosstalk from RX pair to D+/D−

fmax = 1.2 GHz

$$\mathrm{IDDXT\_2NEXT} = dB\left(\sqrt{\frac{\int_0^{f_{max}} |Vin(f)|^2 (|NEXT1(f)|^2 + |NEXT2(f)|^2) df}{\int_0^{f_{max}} |Vin(f)|^2 df}}\right)$$

where:

NEXT1 = Near-end crosstalk from TX pair to D+/D−

NEXT2 = Near-end crosstalk from RX (the RX functioning in TX mode) pair to D+/D−

fmax = 1.2 GHz

The integration shall be done for NEXT + FEXT and 2NEXT on D+/D− from the two differential pairs located at A2, A3, B10 and B11 (see Figure 2-2) and for NEXT + FEXT and 2NEXT on D+/D− from the two differential pairs located at B2, B3 A10 and A11 (see Figure 2-2). Measurements are made in two sets to minimize the number of ports required for each measurement.

The integrated differential crosstalk on D+/D− shall meet the following requirements:

- IDDXT_1NEXT + FEXT ≤ −34.5 dB,
- IDDXT_2NEXT ≤ −33 dB.

3.7.2.4.5 Integrated Return Loss

The integrated return loss (IRL) manages the reflection between the cable assembly and the rest of the system (host and device). It is defined as:

$$IRL = dB\left(\sqrt{\frac{\int_0^{f_{max}} |Vin(f)|^2 |SDD21(f)|^2 (|SDD11(f)|^2 + |SDD22(f)|^2) df}{\int_0^{f_{max}} |Vin(f)|^2 df}}\right)$$

where *SDD21(f)* is the measured cable assembly differential insertion loss, *SDD11(f)* and *SDD22(f)* are the measured cable assembly return losses on the left and right sides, respectively, of a differential pair.

For USB 3.2 Gen 1 and USB4 Gen 2 cable assemblies, IRL limit is specified as:

$$IRL \le 0.046 \cdot ILfitatNq^2 + \ 1.812 \cdot ILfitatNq - 9.784.$$

3.7.2.4.6 Differential-to-Common-Mode Conversion

The differential-to-common-mode conversion is specified to control the injection of common mode noise from the cable assembly into the host or device. A mated cable assembly passes if its SCD12/SCD21 is less than or equal to −17 dB from 100 MHz to 10 GHz.